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OGC API STATE OF PLAY - A PRACTICAL TESTBED FOR THE NATIONAL SPATIAL DATA INFRASTRUCTURE IN SWITZERLAND

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ABSTRACT:

Interoperability standards from the Open Geospatial Consortium (OGC) shape a backbone within the OSGeo community by defining a pathway to software implementation toward the standardization of geospatial information and related services ensuring interoperability between FOSS4G software. In 2016, the OGC has initiated the creation of a new generation of standards based on the OpenAPI specifications to facilitate the integration of geospatial data in modern web applications and systems. From a practical perspective this paper intends to address the question how organizations and institutions anticipate to leverage this new generation of standards in order to deploy a geospatial data infrastructure. This issue is at the core of this article and at the center of a project that seeks to address the issue by running a Testbed Platform with a special focus to the Swiss context. To challenge these standards, the Testbed platform is configured to run a showcase with experimental cases about climate change. It is expected to bring good visibility toward all actors concerned by the Swiss standardization process and to raise interest from government stakeholders, technical or not, companies and universities as a community in synergy when considering the advances at the OGC.

1. INTRODUCTION

Recently, in 2022, the Open Geospatial Consortium (OGC) and the Open Source Geospatial Foundation (OSGeo) have renewed their Memorandum of Understanding. While the initial agreement dates from 2008, this renewal is especially motivated by the current focus on the OGC APIs and the will to empower developers (even non-geospatial) to leverage location in their development. Indeed, the OGC has initiated the creation of a new generation of standards based on the OpenAPI specifications to facilitate the integration of geospatial data in modern web applications and systems.

Underpinning the OGC Standards Roadmap, the development of all these standards represents a significant amount of activities carried out by various OGC working groups, Testbeds and pilots from the OGC Innovation Program. Some standards have been approved, many are still under development and it is therefore not always easy to follow the progress. Indeed, while some geodata infrastructures involving national entities, e.g. in Canada (MSC-GeoMet, 2021), are already deploying this new generation of standards, some initiatives run a phase of experimentation such as for instance the Geonovum OGC API Testbed Platform (Geovonum, 2021).

From a practical perspective we can ask the question how organizations and institutions anticipate to leverage this new generation of standards in order to deploy a geospatial data infrastructure. This issue is at the core of this article and at the center of a project that seeks to address the issue by running an OGC API Testbed platform with a special focus to the Swiss context. This project is embedded in the NGDI Resources program related to the Swiss Geoinformation Strategy (swisstopo, 2019) with the purpose to contribute to the upcoming revision of Swiss e-government standards regarding geoinformation such as the eCH-0056 standard (eCH association, 2016b). This project is about a research carried out by academic partners (HEIG-VD, SUPSI, UNIGE) as well as the Federal Office of Topography swisstopo.

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2. SWISS NATIONAL CONTEXT

In Switzerland the exchange and publication of geographic information is governed by the Federal Act on Geoinformation (Swiss Government, 2007). It is accompanied by two regulations:

- GeoIV / OGeo Federal Council Ordinance (Swiss Government, 2008b)
- GeoIV / OGeo-swisstopo specific for the Federal Office of Topography swisstopo (Swiss Government, 2008a)

The GeoIV / OGeo contains the fundamental provisions, while the GeoIV / OGeo-swisstopo regulates the technical details, which can be modified by the competent federal office (swisstopo), with the participation of the cantons and after consultation with different partner organisations:

- eCH a national association for the establishment of e-government standards
- SOGI / OSIG national association for geoinformation
- KGK-CGC organization of the Swiss Cantons in the field of geoinformation management

The GeoIV / OGeo-swisstopo specifies criteria such as the geodetic reference system, the description language for modeling geospatial data, metadata standards for geoinformation and minimal requirements for geodata.

In its 7th article: "Minimal requirements for geoservices", the GeoIV / OGeo-swisstopo refers to the e-Government standard eCH-0056 entitle Application Profile for Geoservices (eCH association, 2016b), which defines the implementation of basic geoservices by means of a set of additional guidelines and recommendations which make the services suitable for practical use. In addition, there are other regulations, such as metadata models (eCH association, 2013) and protocols for the exchange of base geodata under federal law.

As the eCH-0056 document currently refers to the WxS family of OGC specifications (WMS, WMTS, WFS, WCS, CSW, SE, SLD, SOS), our research aims to assess the maturity and the benefits of the new OGC APIs in the perspective of a revision of its legal framework.

3. METHODOLOGY

Given the above general purpose, the intent is to develop knowledge and practice of these OGC API standards so as, for instance, to update guidelines of the instructions stated by eCH-0056. More generally, how can the advances coming out from the OGC standardization process be integrated into the Swiss standardization process and even vice versa. The idea in this project is to setup a Testbed Platform to connect these two processes as illustrated by Figure 1 by considering issues related to how requirements defined by stakeholders are handled by standardization works both sides. By running at each iteration a showcase on specific use cases with a set of standards to challenge, the Testbed Platform brings results as update guidelines (e.g. for eCH working groups in the field of geoinformation) and feedbacks (e.g. OGC Change Requests). In addition, such a vision can provide an opportunity for dissemination and training material creation (e.g. tutorials, workshops).

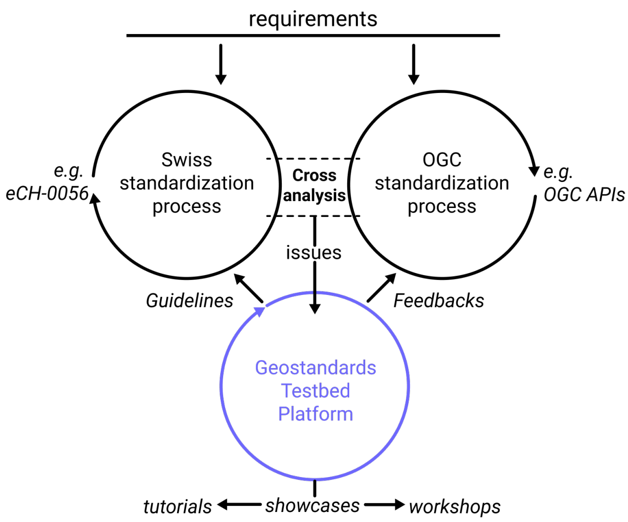

Figure 1. Proposed vision to connect Swiss and OGC standardization processes through a Testbed Platform

Several activities are to be carried out to feed and run such a platform, among them: requirements analysis with stakeholders, identification of underlying standards to challenge, subscription/following in the relevant standards working groups, definition of experimental cases and evaluation criteria, deployment and maintenance of software to run showcases, documentation and dissemination, ...

For this project, to be seen as a first iteration, the expected outcomes include both quantitative and qualitative results that will be compiled into practical e-government guidelines for the implementation of standards from the OGC API family (OGC, 2022). The selected mainstream topic for the showcase and the underlying experimental cases is about climate change. While not yet connected in a complex pilot study, each case represents some of the required components from sensors to portrayal. The study is organized in three parts to challenge standards with software related to: (1) sensors data (2) data discovery, access and portrayal (3) earth observation data.

In term of software, the idea is to offer a unique project entry point for the discovery, experimentation and analysis of the new OGC APIs. To develop the knowledge and practice required, openness is not only related to the standards evaluated, but also required for the software aspects of the Testbed platform. That's why we identified the Geonovum OGC API Testbed tooling stack (Geovonum, 2021) as a good base. It includes already open source packages and provides a detailed documentation available on GitHub. On this basis we deployed a server instance (HEIG-VD, 2021) which still needs to get populated with the underlying data and configured to serve everything required to run the experimental cases, from server to client sides. This solution will also be used to create tutorials in the style of the documentation proposed by Meteo Canada (MSC-GeoMet, 2021).

This solution is expected to bring good visibility toward all actors concerned by the Swiss standardization process. It is to raise interest from government stakeholders, companies and universities, technical people or not, as a community in synergy when considering the advances at the OGC.

To test the experimental cases, FOSS4G implementations are deployed, especially server-side software with:

- FROST (Fraunhofer-IOSB, 2022): focusing on sensor observation standards
- GeoServer (GeoSolutions, 2022): quite active in the implementation of a wide set of OGC API standards
- ldproxy (interactive instruments GmbH, 2022): focusing on OGC API Features as an adapter sitting in front of existing WFS services
- pygeoapi (GeoPython Community, 2019): active in the implementation with the largest set of OGC API standards of the panel
- QGIS Server (QGIS Community, 2022): quite active community in Switzerland, implementing also an OGC API Features client

The choice of these solutions was made to cover all the standards to be challenged in this project as well as with the variety of programming languages of the most common OSGeo software, the ease of deployment and the quality of their documentation. Table 1 has been built by going over the OGC API landing page of each, in conformance with the Landing Page Requirements Class of OGC API Common - Part 1: Core specification.

	FROST	GeoServer	ldproxy	pygeoapi	QGIS Server
SensorThingsAPI (OGC:18-062r2)	x				
Features (OGC:17-069r3)		x	x	x	x
Maps (OGC:20-058)		x			
Styles (OGC:20-009)		x			
Tiles (OGC:20-057)		x		x	
Coverages (OGC:19-087, draft)		x		x	
DGGS (draft)		x			
EDR (OGC:19-086r4)				x	
Processes (OGC:18-062r2)				x	
Records (OGC:20-004)				x	

Table 1. Implementations according to conformance declarations (status as of May 2022)

4. SENSOR DATA

4.1 Sensor Data Standards

In Switzerland there's no official standard defined to share with geospatial interoperability located environmental observations. In fact, the eCH-0056 at section 6.14 *Services de mesure et d'exploitation* indicates the OGC SOS v2.0 and the Sensor Planning Service (SPS) v2.0 as reference standard but indicates that currently no directive or recommendation is in place.

The SOS standard was initially released in 2012. It follows the classical OGC WxS services. It defines interfaces toward sensors (data producers) and users (data consumers) based on the Simple Object Access Protocol (SOAP). Data are encoded in Extensible Language Markup (XML) and are based on the OGC Observations and Measurements (O&M) to represent data and ONT the OGC SensorML to represent sensor description. The standard exposes two main requests for data producers: (1) *RegisterSensor* to add a procedure to the service by means of a SensorML description and (2) *InsertObservation* to inject a new observation using the O&M. To interact with the users SOS offers three main requests: (1) *GetCapabilities* to conform with OGC commons and access metadata about the server, including how to generate requests and what parameters can be used; (2) *DescribeSensor* to access the information in SensorML of a specific procedure that generates the data; and (3) *GetObservation* to download data in O&M format applying filters on sensors, location, time, observed properties and feature of interest.

Due to the extra effort of Web Interfaces to parse and handle XMLs some SOS software like istSOS (Cannata et al., 2019) and 52North-SOS implementations started to develop their own JSON based API. To cope with this problem, in 2015 the OGC developed the SensorThings API (STA) version 1.0 (OGC, 2021b), which is not actually part of the OGC API but share most of the approaches, which are based on the use of RESTful services and JSON format. We can consider this standard as the evolution of the SOS toward the implementation of ready-to-consume services for Web user interfaces. The main difference in the data model (see Figure 2) is the conceptualization of *Datastream* which groups observations measuring the same observed property and produced by the same sensor and of *Things* which is a physical element that is integrated in the communication network (similarly to a Wireless Sensor Network node). STA offers a Representational state transfer (RESTful) API that permits to create, read, update, delete (CRUD) elements using the HTTPS verbs (POST, GET, PATCH, DELETE). Entities are accessed by IDs and URLs. URLs can be extended to interrelated elements and defined query parameters can be set.

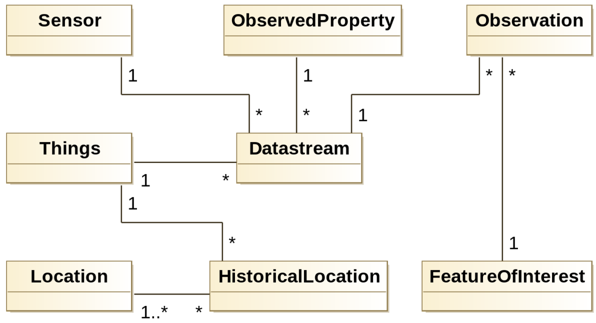

Figure 2. SensorThings API data model

4.2 Environmental Observations and Consuming Applications in Switzerland

Major Swiss authoritative national offices that manage monitoring network for environmental data are: (1) MeteoSwiss, the national meteorological office that collects weather information from the *SwissMetNet* that comprises about 160 automatic monitoring stations observing weather and climate variables and about 100 automatic precipitation stations (Suter et al., 2006); (2) Federal Office for the Environment (FOEN) that use the hydrometric monitoring network composed by about 260 stations observing surface water levels and discharges (Schwanbeck et al., 2018); and (3) Swiss Federal Institute for Forest, Snow and Landscape Research (SLF) that manage the *IMIS (Intercantonal Measuring and Information System)* network comprising 186 stations measuring snow, wind and other avalanche specific parameters.

At the best knowledge of the authors, none of these offices uses any sensor related OGC standards and their Web application for data access are based on specific own non-standard solutions. In most of the cases, the Web application consists in a map with base layers served by OGC WxS services and a static vector layer of the stations localization (GeoJSON or KML) with owner defined metadata. Once a location is selected, the application, using the metadata, compose the URL that points to the observations stored in a static file (JSON, CSV or even PDF). For example, the FOEN exposes on the Web the location of monitored water temperatures as a static GeoJSON (e.g. `https://data.geo.admin.ch/ch.bafu.hydroweb-messstationen_temperatur/ch.bafu.hydroweb-messstationen_temperatur_de.json`) with an id attribute used to later access another static file in CSV (e.g. `https://www.hydrodaten.admin.ch/lhg/az/dwh/csv/BAFU_2167_Wassertemperatur1.csv`) format and containing a series of Time-Value Pairs (TVP). Other similar examples can be found, like MeteoLakes, the online platform for monitoring and forecasting the bio-physical state of Swiss lakes and at MeteoSwiss, the online platform for analysis, forecasting, measurements and data.

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4.3 Testbed actions

The hydro-meteorological monitoring network of the Canton Ticino is currently managed using the Sensor Observation Service (SOS) standard. It has been selected as representative of a practical implementation of basic data required for the climate change impact assessment pipeline. The network, which has a 40 years long time-series, is currently composed of 60 stations and 140 sensors observing precipitation, air temperature and humidity, water temperature, river height. Collected information is operationally used by the local administration to design and actuate water resources protection and allocation to guarantee a sustainable management of the resource and the natural environment while protecting from the impacts of extreme events like floods and droughts. The Sensor Things API operational applicability is evaluated by testing this standard to fulfil all the major in place daily practical operations like for example data quality management, data sharing with third parties, data collection from vendor specific sensors and data analyses and visualization.

At this stage of the research, the FROST implementation of STA has been set up and the data migration scripts has been prepared and are processing the data migration that is not yet completed. Nevertheless, some preliminary considerations can be derived.

4.4 Preliminary results and discussions

The first tested step is the migration of the SOS service to the STA service. To perform this operation a number of mapping and assumption has to be done and consequently a script has been implemented to automatically migrate data. The equivalent of registering a sensor in SOS is the creation of a *Datastream* (POST request) that includes connection with (1) a sensor, (2) an observed property and (3) a things with possibly the location. To do so you therefore need to either have the IDs of the three related elements to be used as a reference, creating them in advance if they do not exists, or include directly the elements in the payload. It is worth to be noted that in FROST, any included elements in the request, if not indicated as a reference, is going to be created regardless the existence of a perfectly equal element. This potentially lead to duplicated elements: think of a set of 10 self registering sensors that measure precipitation, at each registration they will create a new *ObservedProperty* resulting in 10 elements with the same name, definition and description, but with different ID. For this reason the script, register only once the different elements keeping track of the IDs and finally create the *Thing*. After that, the script can start collecting observations from SOS and injecting them on the STA using a POST request of *Observations*. While in istSOS we can register multiple observations at once providing a *swe:DataRecord* in FROST this is not possible, and observations are going to be inserted one by one. This operation make the data migration using standards a slow process, so that the data migration rate is of 1,88 observations/second. For a 20 years long series of 10 minutes data that therefore has 1,051,200 observations this result in a migration time of 22,87 days. It worth to be noted that this rate is not affected by the data retrieval request to SOS since observations are retrieved in chunks of 7 days and only when in memory sequentially injected in a loop of POST requests.

Another aspect to consider is that in istSOS you can register observations of multiple observed properties making use of the *swe:DataArray* and similarly in FROST using the *Multidatastream* extension that represents a complex observation type. While in istSOS you can retrieve the observations of one of the *observedProperties* in FROST you can retrieve them only as a complex observation.

Finally, in general in STA the three elements have a very minimal set of required information, and in this sense remove part of the complexity of SOS. Nevertheless to cope with compatibility it allows to extend metadata with generic fields to be used discretionally by the user to store ”text-like” objects (e.g.: JSON, XML). For example USGS (USGS, 2021) in the *Property* field of the *Things* inserted specific information like *monitoringLocationType* or *hydrologicUnit* that are then used to access data. This makes the solution compliant with STA but this lead to loosing practical interoperability since each agency would use it with non defined metadata (what an *hydrologicUnit* means? where is its definition?).

Future analyses will investigate the performance of Message Queuing Telemetry Transport (MQTT) interface for data migration, the compatibility with data validation procedures and possible implications derived by its adoption.

5. FROM DATA DISCOVERY & ACCESS TO PORTRAYAL

5.1 Background

In the context of data discovery, access and portrayal, the well-known OGC WxS standards WFS, WMS, WMTS have been used for more than ten years and still widely in use. In association with these standards, styling aspects are defined by the standards SLD and SE. These are typically referenced by the eCH-0056 Geoservices Application Profile: WMS 1.3.0 (section 6.7), WMTS 1.0.0 (section 6.8), WFS 2.0 (section 6.9.2), WCS 2.0.1 (section 6.9.3), CSW 2.0.2 (section 6.10), SE 1.1.0 (section 6.11) and SLD 1.1.0 (section 6.12).

For this project part, we focus on standardisation work related to discovery, data access to visualisation, as made available by the OGC API family of standards (OGC, 2022) and according to their versioning mentioned by Table 2. Indeed, the table describes the relationship between the considered OGC APIs and their current equivalents in the context of raster and vector related standards.

OGC API	Version	WxS fashioned
OGC API Features	1.0	WFS
OGC API Maps	0.0.1	WMS
OGC API Styles	1.0.0	SLD
OGC SymCore	1.0	SE
OGC API Tiles	0.0.4	WMTS
OGC API Records	1.0.0	CSW

Table 2. From WxS family to OGC APIs

5.2 Testbed actions

To test and analyze these standards and specifications, two experimental cases are setup:

- with the use of Geoclimate (Bocher et al., 2021), an open source geospatial toolbox that computes a set of urban climate parameters based on OpenStreetMap data. The intent is to publish these parameters with metadata, data and maps using the new OGC APIs

- with the Swiss National geodata models that have been published by the Swiss Government as Minimal Geodata Models (MGM) (Federal Office of Topography swisstopo, 2022) using the Swiss INTERLIS modeling language. It is also mandatory for these models to provide styling and symbology instructions according to a spreadsheet-based model (Figure 3).

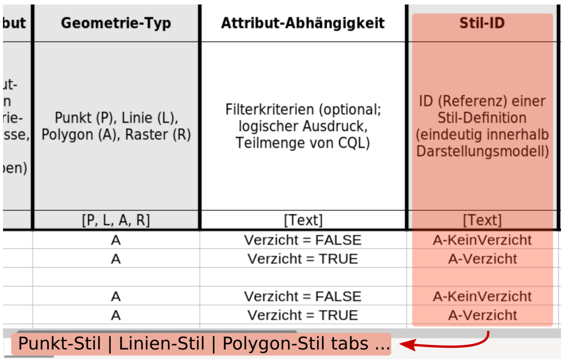

Figure 3. Styling and symbology instructions according to a spreadsheet-based model (*Area reserved for water* MGM)

Such styling and symbology instructions described in spreadsheet may then be formatted according to an encoding in conformance with SymCore extensions and encodings (Bocher and Ertz, 2020).

The encoding example below uses GeoCSS (see Figure 4 that illustrates the rendered result):

```
// @title Espace réservé aux eaux (ERE)
// @abstract
//  According to spreadsheet-based model at:
//  https://www.bafu.admin.ch/bafu/en
//         /home/state/data/geodata-models
//         /water--geodata-models.html

* {
    /* @title ERE */
     [obligation = 1] {
        fill: #ddebf7;
        stroke: #ffcc00;
        stroke-width: 6px;
    }
    ;
    /* @title Renonciation */
     [obligation = 0 ] {
        stroke:#ffcc00;
        stroke-width: 4px;
        stroke-dasharray: 4 4;
    }
    ;
}
```

5.3 First elements to highlight

Regarding the publication of vector data using the OGC API Features standard, we can state that all software packages already support this standard (OGC, 2021a). Regarding the tiling of data sets, for a long time the existing WMTS standard has been largely used, but a standard for vector tiling has never been established up to now. A possible explanation for this lack of standardization is on the one hand the complexity of vector tiling (e.g. regarding the handling of attributes or projections), but on the other hand the success of the Mapbox Vector tiles specification (Mapbox, 2021) that have been widely adopted. The OGC API Tiles specification is on a conceptual level similar to the WMTS standard and defines the addressing and tiling of the data. One difference is that the OGC API Tiles specification allows for several formats (both vector and raster) to be computed. This way of defining tiles assures on the one hand the compatibility with existing WMTS services (i.e. allowing applications to easily integrate both existing WMTS layers with tiled vector layers), but also with the Mapbox Vector tiles specification. On the software side GeoServer already supports the OGC-API tiles specification rendering the formats jpg, png, GeoJSON, topojson and mapbox-vector-tile.

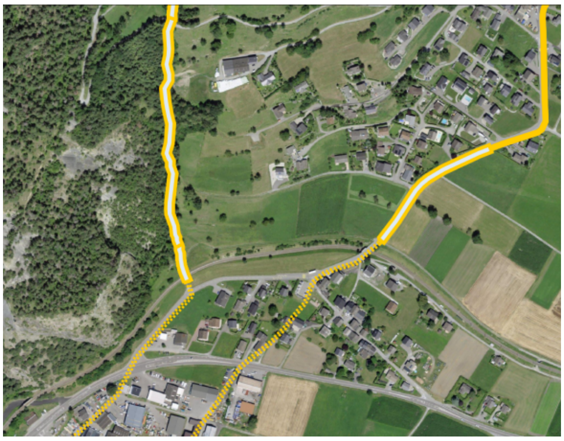

Figure 4. Overview of the *Area reserved for water* portrayal using the above GeoCSS encoding for GeoServer

Concerning portrayal, we may notice two related aspects: about OGC API Styles, about OGC SymCore. Firstly, OGC API Styles is inline with the conceptual model for styles, style encodings and style metadata as documented in chapter 6 of the *OGC Testbed-15: Encoding and Metadata Conceptual Model for Styles Engineering Report*. Especially it states that a style may be made available in one or more so-called stylesheets. Moreover style metadata are made available through the API with general descriptive information about the style, structural information (e.g., layers and attributes), and so forth to allow users to discover and select existing styles for their data. Having several stylesheets available does not guarantee the same visualization of the cartographic result for the final user, because each stylesheet may be based on different models and encodings (e.g. SLD, Mapbox style, GeoCSS, etc). Nonetheless, it opens the possibility to make full use of the cartographic capabilities and richness of the various underlying symbology models.

Secondly, OGC SymCore pushes forward portrayal interoperability with the idea to standardize also the symbology part. The approach is so-called *one conceptual model, many encodings*, which means that many flavors of encodings are possible but each in conformance with a common conceptual rendering behavior of cartographic capabilities. The intent is that finally, independently of the compliant encoding used, the cartographic result will be the same for the final user.

6. EARTH OBSERVATION DATA

Regarding Earth Observation data acquired by satellites, there are some interesting new emerging standards in the OGC API family that are currently being developed. Among the selected standards to be tested, we have considered: Coverages; Environmental Data Retrieval (EDR); Records; Processes; and the Discrete Global Grid System (DGGS). To test these new standards, we have decided to set up a pygeoapi instance interfaced with the Swiss Data Cube, an analysis ready data archive of satellite imagery (Swiss Data Cube, 2017b). As of May 2022, we have developed/tested the following scenarios to use the various APIs mentioned previously using as a source a Normalized Difference Water Index (NDWI) time-series generated with the Swiss Data Cube (Swiss Data Cube, 2017a):

1. Single geotiff and NetCDF (multidimensional) files published as Coverages (coverage API) [done]
2. Series of geotiff files published with the SpatioTemporal Asset Catalog (STAC) [done]
3. NetCDF file exposed with Environmental Data Retrieval (EDR API) to extract time-series of pixel values [done]
4. Metadata (from the SDC GeoNetwork catalog) imported and published using the (Records API) [done]
5. Create zonal stat process to analyze data by canton (Process API) [ongoing]
6. Test QGIS and R plugins to query tested APIs [ongoing]
7. Explore the Discrete Global Grid System [ongoing]

The first test showed that the publication is smooth and somehow easier than with OGC WxS fashioned services making simple the publication of complex and large raster layers. The first tangible result is the release (in April 2022) in production mode of the STAC API to expose the entire content of the Swiss Data Cube (UNIGE, 2022): 38 years (1984-2022) of satellite imagery on Switzerland (Landsat5-7-8-9; Sentinel-1-2) + other national datasets (e.g., Land Cover, Digital Elevation Model).

The API allows to query and access Analysis Ready Data served by the Swiss Data Cube directly in a client application (i.e. QGIS) via a JSON format:


```
{
    "stac_version": "1.0.0", "id": "odc-explorer",
    "title": "Default ODC Explorer instance",
    "type": "Catalog",
    "links": [
    {
      "title": "Collections",
      "description": "All product collections",
      "rel": "children",
      "type": "application/json",
      "href": "http://explorer.swissdatacube.org
                 :5001/stac/collections"
    },
    {
      "title": "Arrivals",
      "description": "Most recently added items",
      "rel": "child",
      "type": "application/json",
      "href": "http://explorer.swissdatacube.org
                 :5001/stac/arrivals"
    },
    {
      "title": "combiprecip_scene",
      "description": "Hourly Precipitation
          Estimation through Raingauge-Radar
          (by GRID-Geneva)",
      "rel": "child",
      "href": "http://explorer.swissdatacube.org
                 :5001/stac/collections
                      /combiprecip_scene"
    }
}
```


Once all the scenarios have been completed, a demonstration instance will be made publicly available to access the different tested API on the Testbed platform.

7. CONCLUSIONS

At the time of writing this article, the standardization process is still in heavy activity to progress on the OGC API standards, with pieces approved step by step. Also we see many software implementing these pieces. Sometimes it is even by supporting the standardization work at the heart as a kind of continuous proof of concept. FOSS4G tribes are particularly active in this field, being it in C/C++, Java or Python.

Considering the utilization of the well-established OGC WxS-standard series, the new OGC standards represent a major step towards interoperability. An example of applications that clearly benefits from this process are hybrid applications that utilize both non-spatial data and spatial data: if yesterday developers had to implement specific service interfaces for spatial data and for non-spatial data for one application, this is more and more simplified thanks to a common architectural style and geostandards. For the latter, we may also notice the general will to keep specifications modular and extensible including a conceptual level and accepting various flavors of formats.

In the past, Switzerland already played an important role in the establishment of geospatial standards due to the federal organization of the country. In the early 1990 the INTERLIS (eCH association, 2016a) standard has been created, the use of which is today required by the law for specific fields (e.g. cadastral data and minimal geodata models that define how different entities exchange data for specific themes). The Swiss Government has invested many resources to build interfaces that allow for a compatibility between the national standards and the international standards, e.g. the eCH-0018 standard (eCH association, 2016c) which specifies an interface between the INTERLIS standard and the OGC GML standard. Due to the regular establishment of new international standards such as the OGC API family, these interfaces need to be adapted.

Therefore and given the geostandards.ch strategy (COGIS, 2021) that states "*sustainable and benefit-oriented standardisation in the field of geoinformation in Switzerland as well as the effective steering of the development of solutions and software tools in the environment of GeoIG and the National Spatial Data Infrastructure (NSDI)*", the Testbed Platform described in this article should be helpful, from the tactical level to the operational level. As such, the Testbed approach is intended to live on through successive iterations.

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